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(54) MAGNESIUM CAST ALLOYS WITH LITTLE TENDENCY TO HOT CRACK

(71) We, NORSK HYDRO a.s. a Norwegian Joint Stock Company of Bygdoy alle 2, Oslo 2, Norway, do hereby declare that the invention for which we pray that a Patent may be granted us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an aluminium containing magnesium cast alloy with little tendency to hot crack which is used for castings which due to their shape or design are particularly liable to hot crack, and to castings made of this alloy.

Magnesium alloys containing 3 to 10% of aluminium and usually 0.3 to 2% of zinc, for instance AZ 91, have several good properties when used for casting purposes, of which may be mentioned adequate fluidity, die castability and also satisfactory mechanical properties at temperatures up to about 100°C.

These alloys are not particularly liable to hot crack, but their field of application would be even wider if the tendency to hot crack could be further reduced, as modern technique of pressure die casting provides possibilities for mass production of a growing variety of cast articles, including articles of such a design and shape as to increase the liability to hot crack, thus requiring an alloy which per se has little tendency to hot crack.

Hot crack may occur in castings in the solid-liquid interface during the process of cooling.

The above-mentioned type of cast alloys have a considerable temperature range of solidification, and consequently stress conditions more easily arise in the casting during solidification, for instance due to hindered contraction occurring when the casting mould and/or the core prevent the free contraction of the casting, and also to contraction distortion in the casting itself. The tendency to hot crack is increased when the various portions of the casting are not cooled at the same rate, which will readily occur when the casting is not of a fairly uniform thickness.

Different ways and means are known to counteract the tendency of cast alloys to hot crack. As to magnesium alloys of the above mentioned type, it is known that variation of aluminium and zinc content has influence on the alloy's tendency to hot crack.

Surprisingly, it was found that adding bismuth to magnesium alloys of the above mentioned type has a very marked effect in reducing the hot crack tendency of the alloy. Tin was also found to have a favourable effect, although not such a strong effect as bismuth.

According to the invention the use of aluminium-containing magnesium cast alloys containing 5.5 to 10% by weight of aluminium, 0.3 to 2% by weight of zinc and 0.1 to 0.4% by weight of bismuth or tin, the rest being magnesium and conventional impurities, is used for casting which due to their shape or design are particularly liable to hot-crack.

Preferably the above alloy has an aluminium content from 7.5 to 10% by weight.

In a preferred alloy the content of bismuth or tin is 0.2 to 0.3% by weight.

The alloy may contain up to 0.5% by weight of manganese, up to 0.5% by weight of silicon and up to 0.5% by weight of copper.

A preferred alloy contains enough beryllium to inhibit burning or oxidisation.

The invention also relates to an aluminium-containing cast alloy having the above speci-

fied composition and to castings made of the said alloy.

The actual proportions of bismuth or tin used according to the invention are below 1%. The experiments carried out show a maximum effect of bismuth at 0.1 to 0.4% by weight of bismuth. The maximum effect of tin is also found to be between 0.1 to 0.4% by weight of tin, although the effect in this case is, as mentioned above, somewhat smaller.

In the following some illustrating experiments will be described:

A. 1) There was made an alloy of AZ 91 type (9% aluminium, 0.7% zinc and 0.2% manganese) containing varying quantities of bismuth and tin respectively. The following table shows the content of bismuth and tin:

% by weight of bismuth	% by weight of tin
0	0
0.10	0.11
0.20	0.30
0.35	0.31
0.40	0.50
0.50	

These alloys were tested as to hot crack in a modified permanent mould of the type described in "Giesserei", *45*, Heft 26 (1958), p. 761—765.

The results will appear from the graph. The ordinate represents the temperature deviation in degrees centigrade from the critical temperature for AZ 91 without bismuth or tin. The term "critical temperature" as used herein means the lowest mould temperature that gives a crackfree test ingot. The curve for bismuth shows a temperature deviation of 70 to 80°C. for an addition of bismuth of 0.2 to 0.3%. This is a very great difference in temperature, which means that the favourable effect of an addition of 0.2 to 0.3% of bismuth to the alloy is considerable.

The graph further shows a similar effect with tin of 30 to 40°C. between 0.1 to 0.4% by weight of tin.

2) An addition of 0.3% of bismuth to an AZ 61 alloy (6% of aluminium, 0.7% of zinc, 0.2% manganese) gave an improvement of 55°C. compared with AZ 61 without bismuth in experiments with the above-mentioned mould.

The alloys under 1) and 2) showed a tensile strength as normal for AZ 91 alloys. Further experiments showed that the addition of bismuth did not give increased tendency to corrosion as tested by dipping in a 3% NaCl solution.

B. AZ 91 alloys with and without bismuth were pressure die cast to a special hot-crack sensitive piece. The tendency to hot-crack was examined in the cast pieces.

Result:

AZ 91: 4 cracks per piece (average for 200 pieces)
3% entirely faultless pieces.

AZ 91 with 0.3% Bi: 3.3 cracks per piece (average for 100 pieces)
7% entirely faultless pieces

It is evident from the above experiments that the hot-crack tendency in aluminium-containing magnesium alloys to a large extent can be prevented by addition of bismuth or tin, particularly bismuth.

WHAT WE CLAIM IS:—

1. The use of aluminium-containing magnesium cast alloys containing 5.5 to 10% by weight of aluminium, 0.3 to 2% by weight of zinc and 0.1 to 0.4% by weight of bismuth or tin, the rest being magnesium and conventional impurities, for castings which due to their shape or design are particularly liable to hot-crack.

2. The use of alloys according to claim 1, in which the aluminium content is from 7.5 to 10% by weight.

3. The use of the alloys according to claim 1 or 2, wherein the content of bismuth or tin is 0.2 to 3% by weight.

4. The use of the alloys according to any one of claims 1 to 3, wherein the alloy is modified to contain up to 0.5% by weight of manganese, up to 0.5% by weight of silicon and up to 0.5% by weight of copper.

5. The use of the alloys according to claim 4, wherein the alloys contain enough beryllium to inhibit burning or oxidation.

6. The use of aluminium-containing magnesium cast alloys substantially as herein described with reference to the examples for castings which due to their shape or design are particularly liable to hot-crack.

7. An aluminium-containing magnesium cast alloy containing 5.5 to 10% by weight of aluminium, 0.3 to 2% by weight of zinc and 0.1 to 0.4% by weight of bismuth or tin, the rest being magnesium and conventional impurities.

8. An alloy according to claim 7 in which the aluminium content is from 7.5 to 10% by weight.

9. An alloy according to claim 7 or 8 wherein the content of bismuth or tin is 0.2 to 0.3% by weight.

10. An alloy according to any one of claims 7 to 9, modified to contain up to 0.5% by weight of manganese, up to 0.5% by weight

of silicon and up to 0.5% by weight of copper.

11. An alloy according to claim 10, containing enough beryllium to inhibit burning or oxidation.

12. A casting made from an alloy, according to any one of claims 7 to 11.

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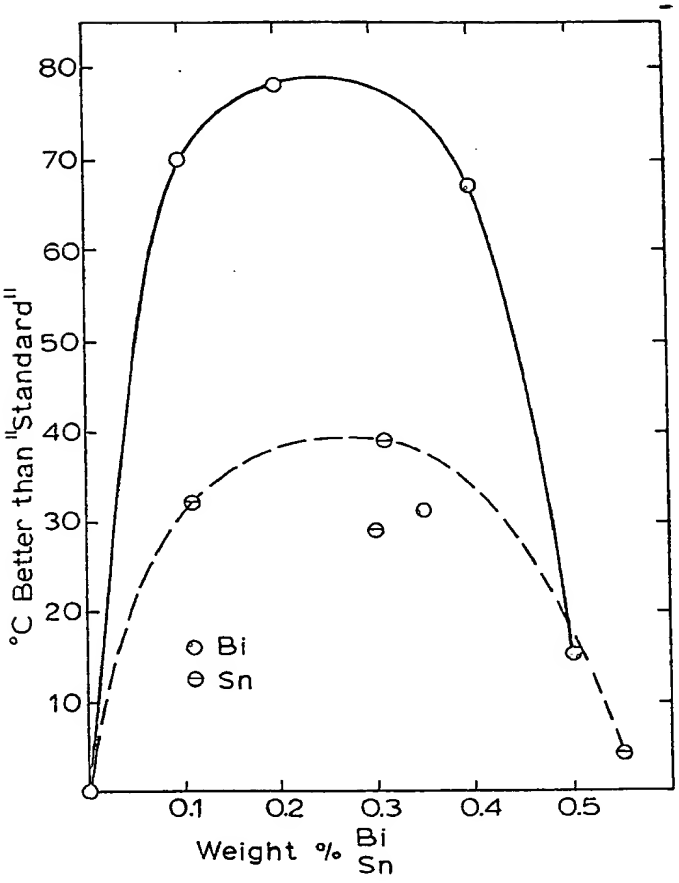
80
70
60
50
40
30
20
10
°C Better than "Standard"
Bi
Sn
0.1
0.2
0.3
0.4
0.5
Weight % Bi Sn